Effect of internal structure of aerosol on particle optics

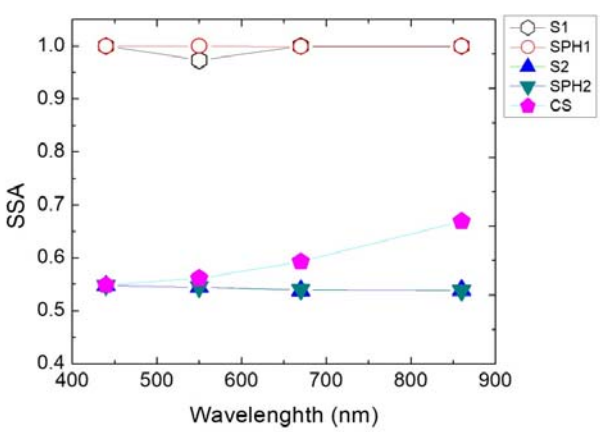
Vikas Goel[a,b], Sumit K. Mishra[a,b*], Ajit S. Ahlawat[a,b], Prashant Kumar[c], T. D. Senguttuvan[a,b], Chhemendra Shrama[a,b], and Jeffrey S. Reid[d]

[a]*Environmental Sciences and Biomedical Metrology Division, CSIR–National Physical Laboratory, New Delhi, India – 110012*
[b]*Academy of Scientific and Innovative Research, Kamla Nehru Nagar, Ghaziabad, Uttar Pradesh, India – 201002*
[c]*Global Centre for Clean Air Research, Department of Civil and Environmental Engineering, University of Surrey Guildford GU2 7XH, Surrey, United Kingdom*
[d]*United States Naval Research Laboratory, Washington DC, USA*

[*]*Presenting author (Vikasgoel1002@gmail.com)*

Aerosol plays a vital role in the Earth's radiation budget by scattering and absorbing the incoming solar radiation. In general, the aerosol particles are considered as chemically homogeneous spheres in the retrieval techniques of ground and space borne observations [1,2]. Here it is noteworthy to mention that the atmospheric particles (especially dust particles) are highly nonspherical in nature [3,4] and the aforesaid assumption may lead to erroneous observations in retrievals. For better simulation of optical and radiative properties of aerosols, a good knowledge of aerosol's morphology, chemical composition and internal structure is essential [5,6].

In present work, we characterize the PM_{10} (particulate matter with aerodynamic diameter less than 10 µm) particles collected form typical arid (the Thar Desert, Rajasthan, India) and typical urban (New Delhi, India) environments. The particles were milled several times to investigate their internal structure. The EDS (Energy Dispersive X-ray Spectroscopy) spectra were recorded after each milling to check the variation in the chemical composition. In arid environment, Fe, Ca, C, Al, and Mg rich shell was observed over a Si rich particle. In urban environment, shell of Hg, Ag, C, and N was observed over a Cu rich particle. Based on the aforesaid observations, different model shapes [single species homogenous sphere (S1) and spheroid (SPH1); multiple species mixture homogeneous sphere (S2) and spheroid (SPH2); and core shell (CS)] have been considered for simulating their respective optical properties.



Spectral variation of SSA for the considered model shapes (S1, SPH1, S2, SPH2 and CS).

In case of Si rich particle having shell of Fe, Ca C, Al and Mg, SSA (Single Scattering Albedo) was calculated for the aforementioned model shapes using core-shell optical models (fig. 1). SSA for CS has been observed to be in between the S1, SHP1 and S2, SPH2. This is attributed to the chemical composition of the respective model shapes. For S1 and SPH1 (only quartz), the SSA tends to 1 while the same found to be reduced (b/w 0.5 to 0.6) for S2 and SPH2 (homogeneous mixture of BC, Fe_2O_3, $CaCO_3$, Al_2O_3 and MgO). The optics of the other analyzed particles will be discussed in detail during presentation.

References

[1] Mishra, S. K., S. N. Tripathi, S. G. Aggarwal, and A. Arola, 2012: Optical properties of accumulation mode, polluted mineral dust: effects of particle shape, hematite content and semi-external mixing with carbonaceous species. *Tellus B* **64**, 18536.

[2] Mishra, S. K., and S. N. Tripathi, 2008: Modeling optical properties of mineral dust over the Indian Desert. *J. Geophys. Res.* **113**, D23201.

[3] Mishra, S. K., *et al.*, 2017: Morphology, mineralogy and mixing of individual atmospheric particles over Kanpur (IGP): relevance of homogeneous equivalent sphere approximation in radiative models. *MAPAN* **32**, 229–241.

[4] Goel, V., *et al.*, 2018: Physico-chemical characterization of individual Antarctic particles: Implications to aerosol optics. *Atmos. Environ.* **192**, 173–181.

[5] Dubovik, O., *et al.*, 2002: Variability of absorption and optical properties of key aerosol types observed in worldwide locations. *J. Atmos. Sci.* **59**, 590–608.

[6] Ahlawat, A., S. K. Mishra, V. Goel, C. Sharma, B. P. Singh, and A. Wiedensohler, 2019: Modelling aerosol optical properties over urban environment (New Delhi) constrained with balloon observation. *Atmos. Environ.* **205**, 115–124.

Preferred mode of presentation: Oral